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BEES AND THE FERTILIZATION OF COFFEE

BY

T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S.,
Imperial Entomologist, Pusa



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BEES AND THE FERTILIZATION OF COFFEE.

The question of the value of bees in coffee districts was raised at the annual meeting in 1911 of the United Planters' Association of Southern India, with particular reference to the effect on outturn of crop caused by the regular destruction of these bees in certain districts (notably the Shevaroyes), such destruction being alleged to cause the very marked diminution in the number of bees which is perceptible in such districts. After some discussion, the following resolution was proposed by the delegate for the Shevaroyes and seconded by the Nilgiri delegate and passed :—

“That Government be asked through the United Planters' Association of Southern India to pass some rules prohibiting the destruction of bees in planting districts.”

2. The object of this resolution was to prevent or diminish the destruction of the bees themselves but not necessarily to place any impediments on the collection of honey or bees-wax. What was asked for was that Government should enforce rules in the coffee-planting districts to ensure that the bees themselves were not destroyed when their produce was taken. It was considered by the planters that it should be possible to take honey and wax without destroying the bees and that the present method of burning the bees off the combs was adopted simply as entailing the minimum amount of trouble.

3. In reply to this request, instructions were issued by Government that the matter should be investigated by the Entomologist. (See G.O. Mis. No. 2062, dated 11th July 1912, and addressed to the Secretary of the United Planters' Association.)

4. In order to determine as far as possible the actual importance of bees in the pollination of coffee, it was necessary to carry out field experiments to test this point. It was also requisite to find out definitely what species of bees were concerned, to what extent they were actually destroyed and how far such destruction had really effected any appreciable diminution in their numbers and, if such diminution seemed the effect of robbing the nests for honey and wax, how this destruction of bees could be minimised.

5. Unfortunately I took over the duty of the newly-created post of Government Entomologist in Madras in April 1912, too late to make any such experiments in that year, as inquiry showed that the coffee had already blossomed in all the coffee districts, and it was necessary to defer the experiments until the next year. In order to gain a preliminary idea of the districts concerned, to find out what bees occurred there and to make local arrangements for the conduct of experiments during the ensuing coffee-flowering season, I paid a visit in October-November 1912 to the Shevaroyes, the Bababudin hills, and to Coorg, and thereafter submitted the following tour report :—

I.—REPORT OF THE GOVERNMENT ENTOMOLOGIST ON A TOUR IN THE SHEVAROYS.

“I left head-quarters on the evening of 13th October, arriving at Salem the same night and proceeded next morning to Yercaud.

Here I examined some coffee and in the evening went on to Hopeville estate.

"On 15th I visited Kadiar rocks, a high rocky cliff to which the wild bees (*Apis dorsata*) suspend their combs, whence a large quantity of honey and wax is collected yearly. In the evening I visited Arcadia estate, where a few colonies of *Apis indica* have been kept in English hives, but unfortunately these had all swarmed and deserted the hives just prior to my visit. Investigation of the combs showed that wax moth (*Galleria mellonella*) had effected an entrance. (See Agricultural Journal of India, October 1911.)

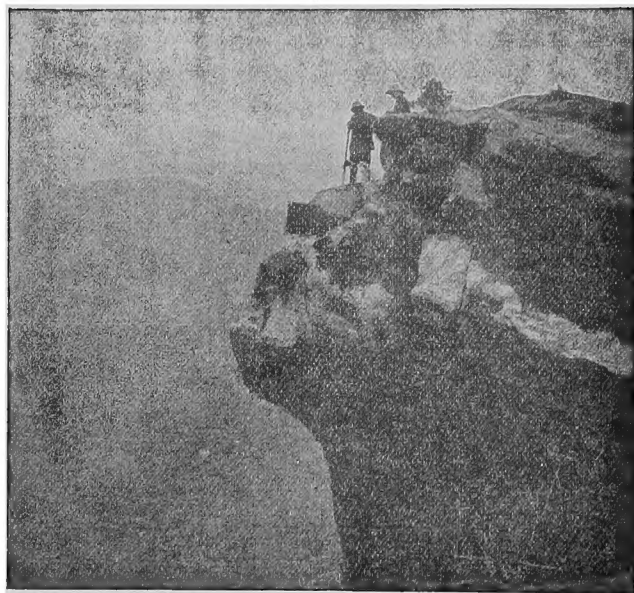


FIG. 1.—Where *Apis dorsata* builds its comb. The Kadiar rocks in the Shevaroy hills. The bees build below the overhanging rock shown here and the honey-gatherers are lowered over the precipice by ropes.

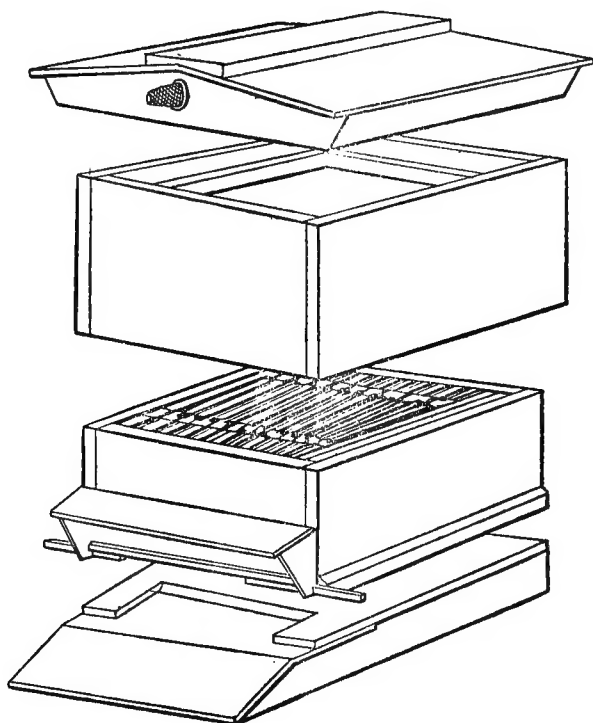


FIG. 2.—Diagrammatic sketch of a bar-frame beehive, showing construction.

" On 16th I observed flower-haunting insects and did some general collecting, visiting Swinton estate and Scotforth estate, to see local conditions and make general observations on insects.

" On 17th I proceeded to Vallakadai Peak estate, collecting and observing in the intervening country.

" On 18th I observed flower-haunting insects, gathered information regarding bees, and saw and advised on various pests of coffee, orchard and garden crops. It was a wet misty day very unfavourable for collecting or observing insects. At about 6-30 P.M. a sharp earthquake shock, lasting about one second, was felt here.

" On 19th, as the north-east monsoon seemed to have set in and it was misty and raining hard, I left for Yercaud, reaching there the same afternoon.

" On 20th (Sunday) I halted at Yercaud. It was a misty, wet, cold day and few insects could be found, but I was able to obtain several interesting species.

" On 21st it was still wet and unfavourable and I left in the afternoon for Salem and arrived back at Coimbatore on the morning of 22nd October.

" Three species of true honey bees (*Apis dorsata*, *indica* and *florea*) appear to occur in the Shevaroy's (I omit consideration of a fourth reported species, which is evidently a *Melipona*). Of these I was unable

to come across a single specimen of *Apis florea*, and neither of the other two species was at all common. The absence of bees in these hills at the time of my visit was indeed remarkable. During the last three or four days the weather was, it is true, extremely unfavourable, yet even this would hardly account for the almost total absence of bees, and I am inclined to suppose that *Apis dorsata* (and perhaps *Apis indica* also) migrate from these hills into the plains during about July-November. This would be in accordance with the habits of *Apis dorsata* elsewhere (notably at Sabour, in Bihar, as Mr. Woodhouse has informed me) but further observations are desirable, as the point is of course not only interesting from a bionomic viewpoint but also of practical importance in considering the damage to these bees caused by the present methods of collecting honey and bees-wax.

"The right to collect these is leased out by the Forest Department, usually to Malayalis living in adjacent villages. The bees (by which I refer to the large rock-bee, *Apis dorsata*) suspend their large single combs from the lower surface of inwardly sloping rocks which occur usually as high cliffs rising for 200 or 300 feet. As these combs are usually affixed to overhanging rocks near the top of such a cliff, the honey-gatherers generally climb down by a rope ladder fastened from the top. Occasionally the ladders break, or the gatherers are so badly stung that they lose their hold and drop, being dashed to pieces on the rocks below. They are provided with a blanket and a torch, with which they burn the bees off the combs, which are then cut and collected. The destruction of bees by this process, which takes place in May-June, is enormous as I am informed by all observers. At the same time, I am doubtful whether the honey and wax could be collected without the destruction of the bees, which would otherwise pursue the plunderers of their stores and exact full vengeance on their disturbers.

"*Apis dorsata* seems to be a fierce and intractable bee whose habit of building a single large comb unfits it for domestication. Its migratory habits also, if these are established, form an obstacle from an apicultural viewpoint.

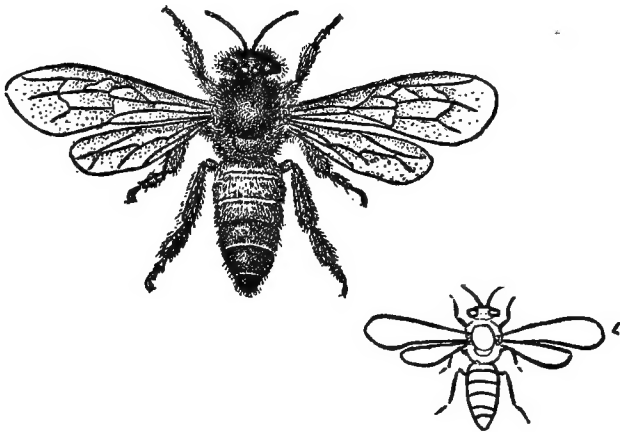


FIG. 3.—*Apis dorsata*, worker. The small outline figure shows the natural size.

"*Apis indica*, a bee rather similar to, but smaller than, the English honey-bee, builds its nest as a rule in hollow trees where it forms several parallel combs. It can be hived, although it is very subject to attack by wax-moth whereupon it usually deserts the nest and swarms off elsewhere, so that it is rare to induce a colony to remain in one hive for more than a few months. The ordinary English bar-frame hive and foundation comb, being made to suit the larger European bees, are hardly suitable for *Apis indica*, whose combs are smaller, averaging about 35 cells in 6 inches, whereas European combs run to about 27. This difficulty may be overcome by the use of specially made foundations and I am writing to Colombo to make inquiries regarding the availability of such for Indian bee-keepers, as I understand

* A foundation machine for *Apis indica* is now available at Pusa and foundation can be made if wax is supplied.

T.B.F.—15-6-14.

that the Ceylon Agricultural Society has recently obtained a foundation machine * specially built to suit *Apis indica*. This bee offers the most likely subject for trial in domestication amongst the native

Indian bees, although, as remarked above, it is not altogether satisfactory. It is at times rather a vicious species, resenting interference and manipulation, and that also is a point against asking coffee planters to endeavour to domesticate it. I presume that its honey and wax are covered by the term "forest products"; but I am unaware whether collection of products of this variety is included under the licenses granted by the Forest Department. In any case, it would prove most difficult to enforce protection for this bee, as it builds almost anywhere in the jungle wherever a suitable hollow tree is to be found and is not confined to special localities as is the rock bee.



FIG. 4.—*Apis indica*, worker. The small outline figure shows the natural size.

"*Apis florea* occurs in the Shevaroys by all accounts, although I saw none at all. It builds a small single comb rarely more than 6 inches broad by 12 deep (often smaller) and is quite unsuitable for domestication. It usually hangs its comb from a branch of a bush where it is easily found and taken and this habit renders it (like *Apis indica*) very difficult to protect by any legislation. It is, though small, a most active little worker and must do a great deal of good in the pollination of flowers. Its store of honey is so small that it is not likely to be taken for commercial purposes but would doubtless be secured for present eating by jungle tribes.

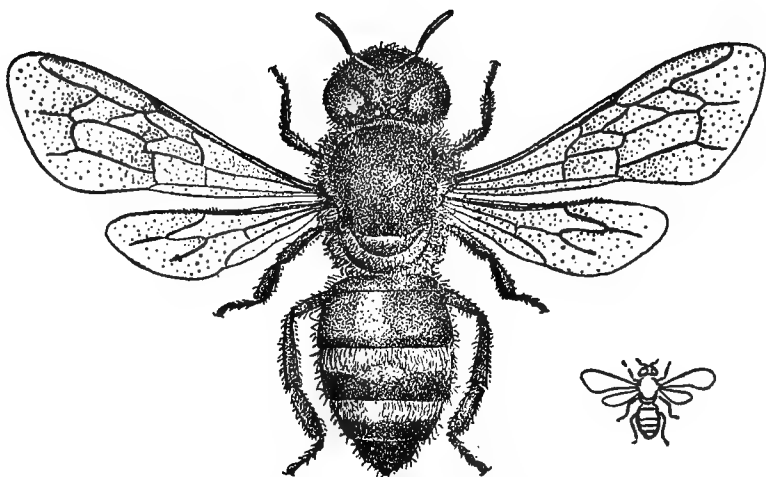


FIG. 5.—*Apis florea*, worker. The small outline figure shows the natural size.

"Although very few bees were to be seen at flowers by day, in the evening numerous moths, notably *Nephele hespera* and *Protoparce convolvuli*, were attracted, whilst in the daytime *Macroglossum* spp. also darted around the blossoms. It will of course be necessary to determine by actual experiment and observation, when the coffee flowers next April, what proportion of flowers are actually fertilized by bees, but I rather expect to find that other insects (such as the sphingids named above) will be found to have a large share in fertilizing them."

II.—REPORT OF THE GOVERNMENT ENTOMOLOGIST ON A TOUR IN THE BABABUDIN DISTRICT OF MYSORE STATE.

"I left Coimbatore on the evening of 30th October and next morning reached Bangalore where I met Mr. G. N. Frattini, the Planting Expert's Assistant for Mysore, and we reached Kadur the same afternoon. Owing to difficulty in obtaining transport, we started from Kadur early next morning and reached Chickmagalur the same afternoon. Next day (2nd November) we went on to the Bababudin hills, where I stayed until 13th November, when I left for Chickmagalur and Kadur and arrived at Mysore on the afternoon of 14th November. Here again there were transport difficulties and it was not until noon on 15th that I was able to start for Sidapur which was finally reached at 3 A.M. next morning. From Sidapur I went to Fairlands estate on 16th November, on 17th on to Margalli, and on 18th from Margalli to Mercara, where I halted for three days. From Mercara my intention was to visit Dunkeld estate, where considerable damage to cardamoms by a scolytid beetle has been reported; but although the distance from Mercara was only some 20 miles, no means of transport were forthcoming and I was reluctantly compelled to abandon this visit. I left Mercara on 22nd November, stayed that night at Santikoppa, and proceeded on to Mysore next day, arriving back at head-quarters on the morning of 25th November.

"The main object of this tour was to make a preliminary survey of the localities visited with a special view to collecting information

regarding the occurrence of honey-bees and other flower-frequenting insects, with regard to their influence on the pollination of coffee. Incidentally, of course, collections of economic and other insects were made and various interesting habits, etc., noted, but this report is not the place for such details. As the conditions are rather different the Bababudin hills and Coorg may be considered separately.

The Bababudin Hills.

“ Three species of true honey-bee occur here—

- (i) The large rock bee (*Apis dorsata*).
- (ii) The Indian bee (*Apis indica*).
- (iii) The small bee (*Apis florea*).

“ The large rock bee builds regularly at a height of about 5,800 feet on the eastern face of the hills, recourse being had to one particular vertical cliff where there is a fair amount of shelter by overhanging rocks. This colony is not a large one, comprising perhaps thirty to forty combs on the average.

“ Fairly definite evidence was obtainable that these bees desert their combs on the onset of the south-west monsoon (about June) and return again with the north-east monsoon (November-December). Beyond the general opinion that they fly off in an easterly direction no information was obtained regarding the locality in which they spend the intervening period. Possibly it is somewhere in the vicinity of Kadur. The swarms which return to the hills at the end of the year seem to be small ones and perhaps the number of individuals on a comb is greatest at the end of the hot weather (April-May). Neither honey nor wax appears to be collected systematically whilst the bees are in the hills. The cliff on which they build is situated well above the limits of the coffee estates on this side of the hills and the bees, so far as I could ascertain, are not interfered with at all. The reason for their migration from the hills in June is probably to be found in climatic causes, the excessive rain in the hills during the south-west monsoon hindering them from foraging for food.

“ The Indian bee occurs fairly commonly, building as a rule in hollow trees. It is noteworthy that in these hills the local race of this bee is much darker than in the plains and this seems to be the case generally in the montane districts of Southern India. The nests are robbed when found and swarms are sometimes taken and kept in earthen pots although I only heard of one case of even this simple form of apiculture.

“ The small bee was not common at the time of my visit and I was only able to find one small colony. Possibly it migrates in the same way as the rock bee. This bee is regarded as stingless by the local inhabitants and the nests are commonly robbed for the honey which is usually squeezed out and eaten on the spot.

“ In addition to the true honey-bees, mention may be made of a large tawny-yellow carpenter bee (*Xylocopa rufescens*) which was found fairly commonly at flowers after dark. None were to be seen in the day time but they began to appear in the evening after sunset and flew freely around flowers long after night had fallen. This habit on the part of a bee was quite new to me but, on looking up the

literature, I find that Colonel Bingham recorded its crepuscular flight (Journal of the Bombay Natural History Society, Vol. VIII, page 388); he also found the nest, which consisted of a series of round cells hollowed out in the end of a decaying log. This bee does not seem to have been recorded from Southern India before, although its peculiar nocturnal habits and comparative abundance (in some localities in these hills at least) may possess some importance so far as concerns the pollination of coffee.

"Special attention was paid to the insects frequenting flowers. Those found in the daytime call for little comment, including the butterflies, bees, flies, etc., usually found. Towards sunset, however, quite a different fauna put in an appearance, the first arrival at the flowers being hesperid (skipper), butterflies and humming-bird hawk-moths (*Macroglossum* spp.). As twilight sets in, these gave way to numerous other sphingids (*Hippotion boerhaviae*, *Deilephila hypoleuca*, *Theretra nessus*, *Herse convolvuli*, *Nephele didyma*, etc.), which flew actively from flower to flower accompanied by numerous smaller moths, especially various species of *Plusia* and others of slower flight. The number of flowers visited in an evening by one of these larger hawk-moths must be very large and it is notable that flowers with very deep nectaries are probably adapted for pollination by means of some of these moths whose tongues in some species (e.g., *H. convolvuli*) are much longer than their whole bodies. I expect we shall find, when experiments are made in the coffee-flowering season, that crepuscular and nocturnal insects such as these play a large part in the fertilisation of the blossom, and it may then be considered whether they cannot be encouraged by the planting of attractive bushes such as Madras Thorn (*Duranta*).

"Nests of a small wasp, called locally 'Berna' or 'Flying Ant' are common in this district, being hung from trees. Though often burnt out as a nuisance, these wasps are probably beneficial by feeding on caterpillars, etc., and rarely attack unless disturbed."

III.—REPORT OF THE GOVERNMENT ENTOMOLOGIST ON A TOUR IN COORG.

"My visit to Coorg was brief and hurried and gave little opportunity for detailed investigations. The three species of honey-bee mentioned above occur. *Apis dorsata* (the rock bee) in this district seems to build on trees rather than on rocks, returning year after year to the same tree, or group of trees, upwards of a hundred combs being sometimes suspended from the branches of a single tree. I saw such a favourite tree on Fairlands estate, although at the time of my visit it did not contain more than about 30-40 combs, and these all unoccupied, showing that migration is also the rule in this locality. From inquiries it appears that at the present time there are fewer of these "Bee tress" than there used to be, and that the number of the combs in each tree has also decreased. It is possible that this is directly due to the development of the coffee estates which do not favour the growth or preservation of trees suitable for these bees to build on. The combs are occasionally robbed, the trees being climbed at night and the combs cut with a knife under the protection of a

torch and a *kumbli*. There appears, however, to be no organised system of destruction of these combs and, where these are situated within estate limits, it is within the power of the planters to put a stop to such practices. There is a large colony of *Apis dorsata* underneath the arches of the Sidapur bridge and, when these combs are robbed, the bees are said to make the road practically impassable for traffic.

"The Indian bee (*Apis indica*) builds in suitable hollow trees scattered throughout the wooded areas. The nests are robbed when found, but are not hunted for systematically.

"The small bee (*Apis florea*) builds in bushes, etc., almost everywhere. The nests are robbed when found, the honey being usually squeezed out and eaten on the spot. It would be impossible to protect this bee, but planters might do something to protect the nests of *Apis indica* on their own estates, as the taking of a nest usually leaves tell-tale evidence of chopped trees, etc."

6. After this preliminary inspection of the areas in question, it was possible to draw up a regular plan of the experiments proposed to be done in April 1913, and the following letter was therefore sent to the Planting Expert on 24th January 1913:—

(i) *Districts in which experiments are to be made.*

"The planting communities of the Shevaroy Hills, Mysore (Bababudins), and South Coorg are the only ones which have so far signified their desire for these experiments to be undertaken in their respective areas. For the present year, therefore, it is proposed to confine the experiments to the districts named above.

"I would point out, however, that the value and interest of any experiments and observations of this nature would be considerably enhanced if they could be checked by comparison with similar experiments and observations in other districts (such as the Anamalai Hills and Travancore) where the conditions are apparently more favourable for the successful pollination of coffee. The planting communities of these more favoured districts have not, it is true, seen any necessity for any investigation into this subject, because they are already satisfied with their outturn, but such investigations would perhaps prove of considerable value in considering the possibility of increasing the outturn of the less favoured areas.

(ii) *Staff required to carry out the experiments.*

"I think that, to minimise risk of errors, the experiments should be carried out in duplicate in each district. We shall therefore require two observers each in the Shevaroy, Bababudins, and South Coorg.

"As you are aware, I am at present under orders to proceed to Pusa to take over the duties of Imperial Entomologist as soon as I am relieved here at Coimbatore. As to who my successor will be, or when he will arrive, I am as yet without any information but it is probable that he will reach Coimbatore some time in March. If this is so, it will rather upset the experiments as, if I have got to go to

Pusa just before the coffee-flowering season, it will be practically impossible for me to leave again at once to come down for these experiments. I might be able to take over charge by telegraph and remain down until after the experiments, but this course would require special Government sanction. In any case, at present, I cannot make any *definite* arrangements about my own share until I hear reliable news about my successor. I would propose, however, that—

(a) The Government Entomologist (either myself, if still here, or my successor, if he has then arrived) should carry out one set of the experiments in the Shevaroyes.

(b) The Assistant in Mysore (Mr. Frattini) should carry out one set in the Bababudins.

(c) The Assistant in Coorg (Mr. Jonas) should carry out one set in South Coorg.

“A second experimenter in each district will therefore be required to carry out the duplicate set of experiments, and I shall be glad if you will be good enough to ask the secretaries of the planters’ associations concerned to secure a reliable volunteer in each district and to let me know his name and address so that the necessary apparatus may be sent to him direct.

“Should I be relieved before the flowering season and allowed to stay down here to carry out these experiments, I would suggest that I should myself revisit the Pollibetta district in Coorg and make an extra set of experiments and observations in that district. As, however, it is at present doubtful whether this will be possible I cannot offer to replace one of the regular experimenters and my functions would only be *supplementary* to theirs”

(iii) *Time of flowering-season.*

“I understand that the flowering season of coffee, which is very short—only of three or four days’ duration at the utmost—follows about ten days after the early rains, commonly called blossom showers, and that these usually arrive any time between about 20th March and 10th April.

“I do not know whether there is much variation in the coincidence of these blossom showers in the three districts concerned, but I would recommend that the secretaries of the planters’ associations concerned should inform me by telegraph (a) when the banking of clouds seems to herald the approach of these showers, and (b) when the showers actually fall, giving in the second case an estimate of the date on which the blossom will be open.

“From here the Shevaroyes are distant roughly one day, the Bababudins three days, and South Coorg four days, and the experimenters and observers should be ready two or three days beforehand. At the same time the secretaries should similarly warn the local assistants and volunteer helpers to be in readiness.

“The first information required above under heading (a) would enable me to get touring apparatus, etc., prepared and, if necessary, to recall to head-quarters any of my staff who might then be away and be required for the work.”

(iv) *The experiments proposed to be done.*

"The experiments proposed to be done are shown in a tabular form in an appendix.

"The bags referred to will be made of two kinds of material (A) fine muslin, and (B) mosquito netting, but all will be of the same size, four feet by two feet, rectangular in shape.

"These bags are intended to be tied around selected branches of coffee-bushes for the various periods shown under the different experiments, to prevent pollination by particular insects at the different times quoted.

[The letters (A) and (B) refer to experiments with muslin and mosquito-net bags, respectively.]

"The experiments intended to be tried are—

I. The bag to be applied before the buds open and kept applied during the whole flowering season, thus acting as a check on pollination by (A) all insects and wind, and (B) all except minute insects.

II. The bag to be applied daily from dawn to dusk throughout the flowering season, the bag being removed and the flowers left exposed from dusk to dawn. This will act as a check on pollination by all day-flying insects. (A) and (B).

III. The bag to be applied daily from dusk to dawn throughout the flowering season, the bag being removed and the flowers left exposed from dawn to dusk, thus checking pollination by crepuscular and nocturnal insects. (A) and (B).

This experiment is the opposite of II.

IV. The bag to be applied daily from 7 A.M. to 5 P.M. throughout the flowering season, the bag being removed and the flowers left exposed from 5 P.M. to 7 A.M., thus checking pollination by honey-bees chiefly. (A) and (B).

V. The bag to be applied daily from 8 A.M. to 4 P.M. throughout the flowering season, the bag being removed and the flowers left exposed from 4 P.M. to 8 A.M., thus checking pollination by all insects flying in the hot sun (*e.g.*, mostly butterflies, syrphids, etc.). (A) and (B).

VI. The bag to be applied daily from 4 P.M. to 10 P.M. throughout the flowering season, the bag being removed and the flowers exposed from 10 P.M. to 4 A.M., thus checking pollination by crepuscular insects (chiefly, sphingids). (A) and (B).

VII. The bag to be applied daily from 8 P.M. to dawn throughout the flowering season, the bag being removed from dawn to 8 P.M., thus checking pollination by all nocturnal insects (A) and (B).

Note.—It would have been better to have applied these bags from 8 P.M. to 4 A.M., but it would probably be difficult to get this done at 4 A.M. As a matter of fact, there seem to be very few insects about in the hills between 4 A.M. and dawn.

VIII. Bag to be applied during the whole time that the flowers are out. The flowers of the enclosed branch to be pollinated by hand with pollen from flowers on this same branch.

IX. Bag to be applied during the whole time that the flowers are out. The flowers of the enclosed branch to be pollinated by hand with pollen from a different bush.

Note.—In experiment VIII the flowers will probably be best pollinated by taking and applying the pollen on a camel-hair brush, which should be carefully sterilized beforehand by immersion in spirit.

In experiment IX the flowers may be pollinated with a brush (as in VIII) or by shaking pollen from a branch taken from another bush. In the latter case, care must be taken that no insects are shaken on to the branch which is to be bagged.

In experiments VIII and IX only muslin bags will be used as the idea is to exclude pollen carried by wind. For this reason care should be taken as far as possible to pollinate by hand when the air is calm; the early morning would probably be the most suitable time if pollen is available then.

Care will have to be taken as far as possible that all branches bagged are free from insects at the time the bags are applied. Care must also be taken that the bags themselves are empty of insects when applied to the branches.

"I have no information regarding any special time or stage at which the pollen grains are liberated. Possibly some of the planting community may be able to tell us about this; otherwise it will require observation to find out the proper time to pollinate by hand in experiments VIII and IX. Some plants only liberate their pollen-grains within very circumscribed limits of time; e.g., between 4 and 7 A.M. in the case of *Hibiscus*. The times may also vary according to local conditions."

(v) *Controls.*

For a proper estimation of the results of the experiments, it is essential to have controls, i.e., branches exposed to exactly similar conditions except for the bagging. For each experiment, therefore, two similar bushes should be chosen beforehand, each having branches similar to one another as regards size, situation (exposure to sun and wind) and promise of flower; one of each of these branches will be bagged for the experiment, the other left untouched and treated as the control of the first.

(vi) *Labelling*

For accurate identification, at the time and afterwards, of the branches, both of those under experiment and of those used as controls, it is essential that they be plainly labelled. It must be remembered that the actual results of the experiments cannot be ascertained until some months afterwards when the berries are full-grown. For labels, I would recommend slips of smooth wood, fastened by wire on to the branches to which they relate. If the details are boldly written on both sides of the labels in pencil, they should remain legible throughout the monsoon. Wood slips about 4 inches by 2 inches, planed smooth on both sides, would be of suitable size. Thirty-two of these will be required for each set of experiments; 64 for each district.

As these can easily be made locally, I would suggest that the secretaries of the planters' associations concerned should have them ready beforehand (by 15th March), with the necessary wire for affixing.

The same number of bushes will also have to be selected in readiness beforehand and I would suggest that the secretaries or experimenters should have this done also by the same date.

(vii) *Observations of insects visiting coffee-flowers.*

"The experiments may usefully be supplemented by direct observation of the insects actually visiting the coffee bushes whilst these are in bloom.

I propose, that in each district, a representative collection of these insects shall be made and as, for this to be done properly, continuous observation and collection from early morning until after dusk will be necessary, this work will take up one man's whole time. For this therefore, I propose to send a member of my staff to each district; but if this is done, arrangements will have to be made for their accommodation. They would of course provide for their own food. The men, I have available, are two assistants and two fieldmen. The assistants are Brahmins and University Graduates; the fieldmen are both Native Christians. I shall be glad to know whether districts have any particular preference for either class of men.

Should I myself be free to visit Coorg (as proposed above) I shall propose to give my time chiefly to observation work of this kind, as a supplementary worker."

Summary of experiments.

Serial number.	Bags applied to selected coffee-bushes.	Series A (Muslin bags).	Series B (Mosquito-net bags).	Object of bagging.
I	Whole time that flower is out.	1	1	Check for pollination by all insects.
II	Dawn to dusk	1	1	Check for pollination by all day-flying insects.
III	Dusk to dawn	1	1	Check for pollination by crepuscular and nocturnal insects.
IV	7 A.M. to 5 P.M.	1	1	Check for pollination by bees chiefly.
V	8 A.M. to 4 P.M.	1	1	Check for pollination by all insects flying in hot sun (e.g., mostly butterflies, syrphids, etc.).
VI	4 P.M. to 8 P.M.	1	1	Check for pollination by all crepuscular insects.
VII	8 P.M. to dawn	1	1	Check for pollination by all nocturnal insects.
VIII	Whole time that flower is out.	1	..	Self-pollinated by hand with pollen from some bush or branch that is enclosed in this one bag.
IX	Whole time that flower is out.	1	1	Cross-pollinated by hand with pollen from a different bush.

Series A is especially to prevent pollination by all insects and wind.

Series B is especially to prevent pollination by all large insects (e.g., honey-bees).

7. In accordance with my proposals, it was arranged that a duplicate set of experiments should be done in each district, and that a member of my staff should also be sent to each district to observe the insects frequenting the flowers. The following were the observers :—

District.	Experiments.		Observing insects.
	Original.	Duplicate.	
Shevaroyas ..	Government Entomologist, Yercaud.	C. Dickins, Nagalur.	Y. Ramachandra Rao, Entomological Assistant.
Bababudins ..	G. Frattini, Assistant Scientific Officer.	N. G. B. Kirwan.	P. Susainathan, Entomological Fieldman.
Coorg (Sidapur).	W. Jonas, Assistant Scientific Officer.	G. Newbery ..	T. V. Ramakrishna Ayyar, Entomological Assistant.

8. In spite of the fact that these experiments were arranged for in duplicate, unfortunately it happened that results are only available from two of them—those carried out by myself and by Mr. Kirwan. Mr. Dickins' experiments were done carefully but a subsequent very heavy hail-storm did so much damage to the bushes that the experiments were nullified. I understand that Mr. Newbery did carry out experiments but he has not sent in any results ; from a brief conversation with him during my recent visit to Coorg, however, I gathered that his results were on much the same lines as those done by myself and Mr. Kirwan. Neither Mr. Frattini nor Mr. Jonas carried out the experiments, so far as I am aware—at least, no results have ever been forwarded.

9. *The Yercaud experiments.*—Having received advice that the coffee was about to blossom, I reached Yercaud on 23rd April 1913 and found the flowers still in bud and not yet opened. Suitable bushes were selected and branches were carefully covered with muslin and mosquito net bags, as previously arranged, and the branches labelled with permanent wooden labels ; other branches, in each case on the same bush and as similar as possible in size, shape, position and promise of blossom, were also selected as controls and labelled. The earliest flowers commenced to open on 25th April and the regular routine of applying and removing bags was started and continued regularly until 3rd May, by which date all the flowers were over and withered, and the bags were then removed from all experiments except Nos. IB, VIII and IX which were unbagged on the next day. At this time all the flowers were quite over, all withered and many dropped off ; no bees were to be seen on the bushes and it seemed doubtful whether the few odd late flowers were still yielding any pollen.

10. I revisited Yercaud on 17th December 1913 to examine the results and collect the berries. These, however, were very non-uniform in ripeness, some being ripe and dropping off the bushes, others still quite green and unripe, and a few not yet full-grown. To

obtain strictly uniform results, all the berries should have been picked when properly ripe. To have done this would have entailed my remaining at Yercaud for at least three or four weeks, visiting the bushes every day to pluck the berries as they ripened. I did not feel justified in doing this, more especially because plucking had already commenced and there was considerable danger that an ignorant cooly, by stripping the bushes under experiment, might have spoilt the whole series. There was also danger of losing the ripening berries owing to the attacks of birds and other animals and also to their dropping off under the influence of the cold wet days which were experienced at this time. I therefore picked all the berries of the experimental branches and of their controls, noting their comparative appearances as under:—

RESULTS of experiments at Yercaud.

Number of experiment.	Bag applied to flowers.	Appearance of berries when plucked.	Remarks.
I-A ..	All the time ..	23 plump berries, quite similar in appearance to normal (un-netted) ones. All green except one nearest tip of branch, which is turning red.	There is apparently nothing to choose between experiments I-A and I-B and their controls.
	Control ..	24 berries, all plump, of which 7 are turning red.	
I-B ..	All the time ..	22 plump berries, only one turning red.	
	Control ..	23 berries, of which 3 are less than normal size and 2 are reddened.	
II-A ..	Dawn to dusk.	63 berries, mostly plump and normal and apparently equal to those on untreated bushes, but 8 are much smaller; 22 reddened. But 40 more berries appear to have dropped or been plucked recently as they are only represented by broken stalks, so that the real number of berries developed was approximately equal to control.	No apparent difference between II-A and its control, allowing in the former for broken-off berries which are probably due to birds.
	Control ..	107 berries, of which 14 are smaller than normal and about 28 reddened.	
II-B ..	Dawn to dusk.	37 berries, of which 4 are small-sized and 7 reddened.	Apparently little difference between experiment II-B and control.
	Control ..	33 berries, of which 3 are small-sized and 6 reddened.	
III-A ..	Dusk to dawn.	55 berries, mostly green, of which about 20 look very small and only 4 reddened. The whole branch looks very poor.	Little difference between III-A and control is perceptible.
	Control ..	72 berries, of which about 12 are small and only 3 reddened. The whole branch looks poor.	

Number of experiment.	Bag applied to flowers.	Appearance of berries when plucked.	Remarks.
III-B ..	Dusk to dawn.	149 berries, plump and healthy-looking, of which about 12 are small and only 2 reddened.	Both III-B and its control are healthy-looking branches with little to choose between them.
	Control ..	87 berries, of which about 9 are smaller and only 2 reddened.	
IV-A ..	7 A.M. to 5 P.M.	38 berries, all large and plump and 22 reddened.	IV-A looks better and healthier than its control.
	Control ..	50 berries, of which 6 small and 6 reddened.	
IV-B ..	Control ..	Nil	The labels had been removed and therefore the branches could not be identified.
V-A ..	.....	Nil	These experiments, originally designed to test the influence of insects flying in the hot sunshine between 8 A.M. and 4 P.M., were abandoned as impracticable.
V-B ..			
VI-A ..	4 A.M. to 8 P.M.	Only one small green unhealthy-looking berry. Label had been moved, but the wire which had fastened it was found on a branch (of same bush) with 3 unhealthy-looking berries.	A bad bush with very few berries anywhere. Experiment a total failure.
	Control		
VI-B ..	4 P.M. to 8 A.M.	104 berries, fairly plump on the whole, about 7 small, 1 rotten, 4 reddened. A healthy-looking branch.	Little to choose on the whole between general appearances of VI-B and its control, but the latter was riper—perhaps it was nearer an open space and slightly more exposed to the sun.
	Control ..	A rather small branch with 20 berries, of which 3 small, rest plump and 20 reddened.	
VII-A ..	8 P.M. to dawn.	56 berries, rather below average size, 8 decidedly small and 8 reddened.	Little to choose between VII-A and control on general appearance.
	Control ..	38 berries, rather below average size, 11 small, 7 reddened.	
VII-B ..	.....	Nil	Only the control branch could be found. The label of VII-B had been removed and the branch could not be identified.
VIII-A ..	Whole time (self-pollinated).	68 berries, of fair average size and plumpness as compared with others on the same bush; of these about 7 are small and 14 reddened.	.....
IX-A ..	Whole time (cross-pollinated).	92 berries, all green and plump and of fair average size as compared with others on the same bush; of the 92, 2 are slightly smaller and 2 reddened.	.....

Number of experiment.	Bag applied to flowers.	Appearance of berries when plucked.	Remarks.
X-B ..	Whole time ..	11 berries, mostly plump and green and of fair average appearance in comparison with others on the same bush; of the 11, 3 are reddened and of these 2 look poor.	A duplicate of I-B, a mosquito-net bag being applied all the time, the flowers were out.

11. The berries, both of the branches under experiment and of their controls, were sent to Mr. Anstead, the Planting Expert, who in his letter No. 94, dated 29th January 1914, wrote to me regarding them—

“I have to inform you that I have finished the curing of the coffee berries you sent me from the Shevaroyas. The berries were picked far too green to cure well and I think that nothing can be judged from them as to quality.

“I send you the resulting berries under separate cover and you will see that the result is poor. When all are so bad it is impossible to grade them at all, beyond saying that II-A control, II-B and IV-A are the best and perhaps III-B and VI-B the worst.”

12. With regard to Mr. Anstead's comment that the berries “were plucked far too green to cure well,” I quite agree that this was so, but this seemed to be the best thing to do. To have remained until all were ripe, it would have been necessary to have prolonged my stay in Yercaud at least another three weeks, visiting the bushes daily or even more often and risking loss of many of the berries owing to their dropping prematurely or being detached by pickers or birds or other animals. If I had bags with me, I might have reapplied them to the branches to catch the berries as they dropped, but the chances would have been very large that the bags would have disappeared *in toto* with the pickers working in the coffee all around. I therefore considered that the best thing to do was to pluck the berries as they were, to get comparative results regarding the number and size of the berries.

13. *The Bababudin experiments.*—These were carried out by Mr. N. G. B. Kirwan and are detailed in his letter of 16th January 1914 to the Planting Expert. A copy of this is given below:—

“ARABIDACOO ESTATE,
Chikmaglur P.O., 16th February 1914.

“R. D. ANSTEAD, Esq.,
Planting Expert, Bangalore.

“DEAR SIR,

Bees and coffee fertilization.

“Under separate cover I send the samples of coffee obtained from the above experiment. I regret to say No. 5-B is missing, as on picking the crop I found this label was missing.

"The blossom showers fell on April 18, 20 and 21, totalling 1.10 inches.

"The bags and labels were applied on the evening of the 21st. The experiment commenced on 27th April 1913 and concluded on 29th April 1913 when the bags were replaced for a week.

"During the course of the experiment the following points were noticed:—

"A very large number of bees were about owing to large hives of *Apis dorsata* on the cliffs above the estate. Fifteen to thirty bees were constantly counted on a single tree by the Government Entomologist's fieldman and myself, the proportions of the different kinds of bees being about 55 per cent. *Apis dorsata*, 35 per cent. *Apis indica*, 10 per cent. *Apis florea*.

"The bees completely nullified the experiments to check fertilization by other insects as they entirely failed to keep to their scheduled time. For instance, one bee made a determined effort to attack the branch I was hand-pollinating at 6 A.M. (experiment 8). For experiment 5, the bag should be removed at 4 P.M. At 5 P.M. on the 27th there were five bees on the experiment tree, viz., three *Apis dorsata*, two *Apis indica*. This bag had been removed at 4 P.M.

"In general I especially noticed bees about from shortly after dawn until it was too dark to distinguish them any longer. From dawn till 7 A.M. and 4-30 P.M. till dark the majority of the bees were not out.

"The number of other insects compared with bees was negligible. A point noticed while cross-pollinating experiment 9 was that flowers from a branch of another tree that had been open to insects the day before fell when shaken. The experiment branch, which had been enclosed in the bag the day before as some of the flowers were not out, did not fall when shaken.

"The two trees selected were healthy young Coorgs, about 10-12 years old. As they were carrying a heavy crop a lot was pruned off. In spite of this I regret to say they developed leaf disease in December, and thus to a great extent prevented comparison of the different samples.

"As will be seen in the tabular statement below the quality follows the leaf disease. The branches picked on 7th January were not much affected by the leaf disease. The rest were.

"I had originally intended to count the berries after the blossom, so as to check the loss from the commencement, as should undoubtedly have been done. While carrying out the experiment I found it impossible to entirely eliminate damage to the flowers by the bags. As it was impossible to say accurately what flowers had been knocked by the bags, I did not do this. The accompanying table records the following points:—

Column	1. Number and class of experiment.	{ A. Muslin bag B. Mosquito-net bag. C. Control.
"	2. Time bags were applied.	
"	3. Date picked. January 7 or January 26, 1914.	
"	4. Percentage of ripe fruit.	

Column	5. Number of berries after drying.
"	6. Number of beans of clean coffee.
"	7. Number of pea berry.
"	8. Actual total of beans.
"	9. Possible total of beans (As one normal berry contains two beans but a pea berry only one, this has to be allowed for in counting the loss.)
"	10. Loss.
"	11. Percentage of loss.
"	12. State of branch at time of picking.
"	13. State of sample coffee.

	Bag applied.	Date picked.	Per- centage of fruit.	Number of berries.	Number of beans.	Number of pea berry.	Total beans.	Possible total.	Loss	Per- centage of loss.	State of branch.	Sample.
1	2	3	4	5	6	7	8	9	10	11	12	13
1. A.	Whole time	7th	85	44	53	7	60	81	21	25.32	Normal	Normal.
B.	Do.	7th	100	21	39	1	40	41	1	2.43	Do.	Do.
C.	Do.	7th	57	32	62	1	63	63	..	..	Do.	Do.
2 A.	Dawn-dusk	26th	35	62	114	3	117	121	4	3.32	End dead	} Good size but a little shrivelled.
B.	Do.	26th	47	110	173	21	134	199	5	2.56	Leaf disease	
C.	Do.	26th	37	98	146	24	170	172	2	1.16	Do.	
3 A.	Dusk-dawn	26th	18	102	161	20	181	184	3	1.63	End dead	} Small and shrivelled.
B.	Do.	7th	72	86	124	22	143	150	4	2.66	Normal	
C.	Do.	26th	5	84	93	35	128	133	5	3.75	End dead	
4 A.	7 A.M.-5 P.M.	7th	86	30	42	9	51	51	..	33.73	Normal	Normal.
B.	Do.	7th	61	102	70	38	108	166	56	1.77	Do.	Do.
C.	Do.	7th	78	32	47	8	53	56	..	..	Do.	Do.
5 A.	8 A.M.-4 P.M.	26th	51	81	99	27	126	135	9	6.66	Leaf disease	Good size ; some shrivelled.
B.	Do.	26th	..	..	..	..	..	..	..	..	..	..
C.	Do.	26th	15	71	126	6	132	136	4	2.91	Leaf disease	Small ; some shrivelled.
6 A.	4 P.M.-8 P.M.	26th	49	61	94	11	105	111	6	5.40	Do.	Normal.
B.	Do.	26th	4	55	107	..	108	109	1	91	End dead	Small and shrivelled.
C.	Do.	26th	2	94	155	14	139	174	5	2.87	Leaf disease	Very small and shrivelled.
7 A.	8 P.M.-dawn	7th	66	72	73	32	105	112	7	6.25	Normal	Normal.
B.	Do.	7th	61	99	147	22	169	176	7	3.97	Do.	Do.
C.	Do.	7th	44	96	182	3	185	189	4	2.11	Do.	Do.
8 A.	Whole time (self-pollinated).	26th	18	85	143	11	154	159	5	3.14	End dead.	Small and shrivelled.
C.	Do.	26th	30	92	169	6	175	178	3	1.68	branch dried up	Do.
9 A.	Whole time (cross-pollinated).	26th	24	54	105	..	105	108	3	2.87	Do.	Very small and dry.
C.	Do.	26th	35	39	71	2	73	76	3	3.94	Do.	Small.
				1,702	2,595	324	2,919	3,080	159	5.16		

"There was an undoubted loss of crop on the two branches that were not fertilized at all, i.e., berries that never swelled at all.

Yours faithfully,
N. G. B. KIRWAN."

14. So far as it concerns the actual pollination of the coffee plant, the foregoing experiments appear to show (1) that the aid of insects is not essential but that fertilization can and does take place when all insects are excluded during the whole period that the flower is out, and (2) that wind, and similar natural agencies, are also not essential factors, since the muslin bags used in experiment I-A were of sufficiently fine material to exclude pollen altogether. These results were certainly very unexpected, but some light on the subject seems to be afforded by Dr. von Faber's experiments of which I only became aware after mine had been done, when Dr. Coleman published the following note in the "Planters' Chronicle" (Volume VIII, pages 350—351; 19th July 1913):—

"In 1910, my friend Dr. F. C. von Faber published in Dutch some notes on the biology of the coffee flower in which he gives the results of experiments performed by him on fertilization. He experimented with Liberia coffee and under Javanese conditions so that these results cannot be taken directly as applying to South India. They however suggest a line of investigation which might, perhaps, be profitably followed here in studying the question of the importance of cross-fertilization.

"Dr. von Faber first examined the question of pollination and found that out of 78 flowers of Liberia coffee examined, in all but eight self-pollination had occurred in the bud before the flowers opened; moreover the pollen grains had in many cases, already germinated at the time of opening of the flower and the pollen tubes had begun to grow down through tissues of the style towards the ovaries.

"From this result one might be tempted to conclude that, in the case of Liberia coffee, cross-fertilization can occur in so few cases as to be quite negligible. This is, however, not the case, as, on further investigation, Dr. von Faber found that, where pollen from other flowers on the same plant or from other plants found its way to the stigma and germinated, it grew about twice as fast as the pollen from the same flower. There thus occurs a sort of race between the foreign and the "self" pollen tubes as to which shall fertilize the ovaries and the results depend entirely upon how early the foreign pollen reaches the stigma.

"Dr. von Faber has also some remarks to make on the rôle of insects in the fertilization of Liberia coffee flowers. He states that, although the number of insects in a coffee plantation is usually small in comparison with the number of trees, this is to a certain extent equalized by the rapidity of insect movement, whereby a large number of flowers are visited in a very short time. Bees seem to have been among the most prominent insects observed by him. The following observations made by him are of interest:—

6th April.—Tree No. 8—At 8 A.M., 48 flowers found open; within 15 minutes, 32 of these were visited by insects.

25th April.—Tree No. 7-a—At 8 A.M. 72 flowers found open; within 25 minutes, 48 of these were visited by insects.

14th May.—Tree No. 15—At 8-30 A.M. 64 flowers found open ; within 45 minutes, 52 of these were visited by insects.

14th May.—Tree No. 18-b—At 10-30 A.M. 38 flowers found open ; within 15 minutes, 24 of them were visited by insects.

“The visiting insects were, in each case, examined and were found invariably to be covered with pollen.

“The paper under reference also contains an account of observations on the *robusta* varieties of coffee, where it was found that self-fertilization in the bud rarely takes place. The author found here also that foreign pollen grains grow more rapidly down through the tissues of the style than do the ‘self’ grains.

“With regard to Liberia coffee, the author concludes that cross-fertilization was the original method and that self-fertilization has arisen later to guard against failure in fertilization.

“As far as I am aware, no similar studies have been made on *coffea arabica* either in India or elsewhere and it would, I believe, be a matter of considerable practical interest to ascertain whether a difference in the rate of growth of foreign and ‘self’ pollen grains exists here similar to that described by von Faber for Liberia coffee in Java.”

15. Dr. von Faber’s experiments show that the plant itself expresses a decided preference—if such a phrase is admissible—for foreign pollen ; or, in other words, cross-fertilization is secured whenever possible, self-fertilization being kept in reserve as a last resource. The experiments in the Shevaroy and Babadudins show that there is little difference in the quantity of flowers fertilized by insect-visitors and Dr. von Faber’s paper explains (no doubt correctly) why this is so, but this does not necessarily mean that there is no difference in quality between berries from flowers which have been cross-fertilized and from those which have been “selfed”. The quantity of beans collected from the experiments is too small to ensure a satisfactory comparison of quality, but the endeavour made by the plant itself to secure cross-fertilization strongly endorses the idea that such cross-fertilization is highly desirable—a view which is of course in accordance with experience gained in the case of other plants. We may conclude, therefore, that the visits of pollinating insects should be encouraged as far as possible.

16. Turning now to the insects which secure such cross-fertilization in coffee, before carrying out the experiments, I endeavoured to find out what information was available regarding such insect-visitors of coffee in India, but the information available proved to be most remarkably scanty. Knuth’s “Handbook of Flower Pollination”, to which one naturally turns for information on such a subject, gave very little information on this point, as is shown by the following extract (English translation, Volume II, page 549) :—

“*Coffea arabica*, L.—According to Bernoulli (Bot. Ztg., Leipzig, XXVIII, 1869, page 17) only small purely female fertile flowers are present at the beginning of anthesis. Ernst states that the hermaphrodite flowers are protandrous.

“Visitors—Bourdillon chiefly observed Lepidoptera (Nature, London, XXXVI, 1887).”

17. Reference to Bourdillon's original paper, however, showed that this had been considerably misquoted by Knuth, as Bourdillon referred specially to bees and mentioned Lepidoptera only as subsidiary agents in pollination. The following is a copy of the original letter ("Nature" XXVI, 580; 20th October 1887):—

"I send you the following notes on the fertilization of the coffee plant (*C. arabica*) which I made sometime ago, and which may be interesting to those who study the subject.

"Your readers are doubtless aware that coffee was cultivated some twelve years ago to a very large extent in Ceylon and South India, but owing to the attacks of leaf disease, the area has been rapidly reduced, except, I believe, in some parts of Coorg and Mysore, where the climate is drier, and the leaves suffer less from the fungus. It has now been largely replaced by tea.

"The jasmine-like flowers of the coffee are borne in clusters in the axils of the leaves, and appear simultaneously all over the estates. After a prolonged drought of one or two months, or even more, at the beginning of the year, there is generally a heavy fall of rain, sometimes lasting only an hour or two, sometimes continuing for two or three days: the amount that falls must be enough to saturate the ground, and should not be less than one inch.

"In from six to eight days from the time of the first shower, the flowers burst into full blossom, last for a day, and then drop off. On the evening before the blossom is fully out, if the flowers are examined it will be found that they are partially open, the stigma being protruded and receptive. During the night the hum of insects can be distinctly heard, and I am of opinion that the flowers are largely fertilized by night-flying insects which carry pollen from those flowers which happen to be open rather before the others, as some are delayed. On the following morning all the flowers will be found open, and the field of coffee presents a sheet of white. These flowers are frequented by immense numbers of bees, of two kinds, one about three-quarters of an inch long and black, the other smaller and with white bands round its abdomen. The stigmas now are covered with pollen, and the anthers bursting, and the larger of these bees may be seen buzzing from flower to flower sweeping up the grains of pollen between its front legs, and rolling them into balls. Long before evening all the anthers are exhausted of pollen, and the insects have departed. Besides bees, some butterflies visit coffee, such as *Hypolimnas bolina*, *Papilio polymnestis*, and two or three *Danaidæ*.

"The coffee plant by being proterogynous is intended by nature to be cross-fertilized but owing to all the plants in one clearing being usually grown from seed of a single estate, there must be a great deal of interbreeding, more especially as all the coffee of Ceylon and most of South India is supposed to be descended from a single plant introduced into Batavia about two centuries ago. This may have something to do with the manifest deterioration in stamina of the younger coffee.

QUILON, S. TRAVANCORE, INDIA,
13th September 1887.

T. F. BOURDILLON."

18. The larger bee referred to above is evidently *Apis dorsata*, the smaller one *Apis indica*.

19. My own observations on the insects frequenting the coffee flowers at Yercaud in April 1913 were necessarily scanty, as my time was occupied with the experiments, but the following notes were made :—

Apis dorsata (the large rock bee) was in comparatively small numbers, collecting pollen in the morning as a rule, and nectar in the afternoon. One which was watched when gathering nectar visited ten flowers (all on the same bush) in one minute.—Another specimen, which was collecting pollen, was observed to visit about 22 flowers in one minute, this number including those which it crawled over and might therefore have fertilized ; in a second minute the same bee visited about twenty flowers. When collecting pollen the bees visit far more flowers (approximately twice as many) than when collecting nectar, as in the former case they often crawl all over a bunch of six or seven flowers, whereas in collecting nectar they generally fly straight from one flower to another. There seemed to be more specimens of *Apis dorsata* on the flowers towards the end of the flowering period than at its commencement.

Apis indica (the Indian bee) was fairly common, appearing on the wing at sunrise (6.0 A.M.) and working until after sunset. They gathered pollen chiefly in the morning and nectar in the afternoon. When gathering nectar about ten flowers per minute are visited, and about twice this number when collecting pollen. When sucking the nectar, *Apis indica* often touches the stigmas with its legs as it arises from the flower. Its habit of visiting flowers erratically (as often as not flying off one flower on to another one on a different branch, albeit of the same bush) has doubtless considerable value in securing cross-fertilization. When sucking nectar, *Apis indica* does not quiver its wings, but remains motionless except for extension and retraction of the abdominal segments. When collecting pollen, the bee usually does not settle on the flower but hovers over it and scrapes the pollen off the stamen by embracing it with its mid-legs and drawing these upwards, thus rubbing off the pollen which sticks to the legs and is then scraped off and passed to the regular pollen baskets of the hind-legs. In pollen-gathering there is more chance of fertilizing the flower because the legs hang down when the bee is on the wing and may (and sometimes do) touch the stigma when moving from one flower to another or hovering over a flower scraping up the pollen-grains.

Apis florea (the Little Bee) was not common and no exact details were noted, but their whole bodies appeared to be covered with pollen-grains.

Xylocopa tenuiscapa (a large blue-black Carpenter Bee) was fairly common and very active in visiting the coffee flowers, although I noticed some which were busy on Potato Creeper (*Solanum*) to the entire exclusion of the adjacent coffee. These large bees sprawl all over the flowers, carrying pollen all over their ventral surface ; they often go right up or down a twig, crawling over every flower and probably pollinating every blossom which they touch.

20. Butterflies seemed to be unimportant as pollinators. *Danaïs genutia* was seen to visit the flowers and to touch them with its legs and may pollinate, and *Hypolimnys bolina* and a small brown Hesperid were also noted to feed on the nectar. A *Neptis* was common amongst the coffee but settled by preference on the leaves and was not seen to visit the flowers. A few other butterflies, belonging to the genera *Junonia*, *Ypthima*, *Mycalesis* and *Terias*, were also noted amongst the coffee but not as flower-visitors.

21. A day-flying clear-winged Sphingid moth, *Cephonodes picus* visits the blossom and feeds on the nectar with outstretched tongue whilst it hovers on the wing, but its rapidity of flight and wariness made exact observations difficult. It did not, however, appear to touch the stigma at all with its tongue. This moth, it may be added, lays its eggs on coffee, the caterpillar feeding on the leaves.

22. After dusk a few Sphingid and other moths visited the blossom. They could generally be heard rather than seen, but their number seemed very small—certainly less than I had expected.

23. A few specimens of a yellow-spotted Cetoniid beetle, *Clinteria auronotata*, were found on the bunches of flowers, where they were licking up the pollen systematically by the aid of the brushes on either side of the mouth. Probably these beetles thus eat up a good deal of pollen (as the bees also collect it) but do good by sprawling over the flowers; however, no pollen was visible on the bodies of the beetles.

24. The other insects noted were in such small numbers that they may be regarded merely as casual visitors of little practical importance so far as pollination is concerned.

25. There was no doubt in my mind, from what I saw of the insects which were frequenting the blossom, that the bees (*Apis dorsata*, *Apis indica*, *Apis florea*, and *Xylocopa tenuiscapa*) are the only really important pollinators of coffee. The movements of the Honey-bees (*Apis* spp.) are generally rather erratic, as they buzz apparently at random from one flower or branch or bush to another, thus securing a large measure of cross-pollination, whilst the Carpenter-bees (*Xylocopa*) are most systematic in their mode of working over the bush, whilst they are literally dusted over with pollen and sprawl about over the flowers.

26. I attach the reports on the insects noted on coffee-blossom in the Shevaroy and in Coorg by the two Entomological Assistants sent to those localities for this purpose.

- (1) *Report on a tour to Yercaud, Shevaroy, by Y. Ramachandra Rao, Entomological Assistant (April-May 1913).*

“Under orders of the Government Entomologist, I started from Coimbatore on Sunday the 20th April 1913 by Mail for Yercaud via Salem. I reached Yercaud the next day at about 9 A.M. The object of the tour was to make accurate observations as to which insects visit coffee flowers, when they are most active and whether they are really useful in the fertilization of the flowers. When I arrived at Yercaud the branches of coffee plants were covered with plentiful

flower buds in various stages of growth, but none of the blossoms had yet opened. In fact, the first flowers opened only on the morning of the 25th April. By the 27th, all the estates in Yercaud were in full bloom and presented a sight of wondrous beauty with their exuberant masses of pure white sweet-scented flowers. Flowers generally faded away on the 4th day, so that by the 1st May most of the blossoms had either dropped down or faded, but scattered bushes that had burst into blossom later still had fresh flowers on the 2nd and 3rd May.

"2. Observations as to flower-visiting insects were made on and off between 6 A.M. and 7 P.M. during daytime and as far as possible, specimens of insects noted were collected. On two nights, I examined coffee bushes between 8 P.M. and 9 P.M. with the aid of a lantern, but though I found a few moths flying about, I was unable to ascertain whether they came to flowers at all, as, disturbed by the brightness of the light, they either came to it or flew away. My observations, therefore, as regards the night-side of the question are scanty.

"3. The following were the flower-visiting insects that I noted at Yercaud :—

Hymenoptera :—

(i) *Bees* :—(1) *Apis indica*—the most common of the bees at Yercaud. It was found on flowers from 6 A.M. up to nearly 6-30 P.M. It was the only bee that was found at all in plenty. It was, however, not present in sufficiently large numbers, there being generally not more than 2 or 3 on the average on each bush at a time. This bee was at times found confining its attention to nectar and at other times merely gathering pollen.

(2) *Apis dorsata*.—(The Rock Bee). This was rather scarce at Yercaud on coffee flowers. I did not notice it at all in some estates and where present it was not plentiful. It was most active at midday.

(3) *Apis florea* : found in small numbers on most estates, but is not so scarce as *Apis dorsata*. Like *Apis indica*, this bee was noted confining its attention at times to nectar alone and at other times busying itself solely with pollen-gathering, every anther being regularly scraped up for the purpose.

(4) *Halictus* sp.—Noted only on one occasion. It was collected while gathering pollen on a coffee flower.

(5) *Ceratina* sp.—Only two instances of this bee visiting coffee flowers were noted. It was common, however, on certain small labiate plants in open places.

(6) *Anthophora* sp. found visiting coffee on only one or two occasions. Specimens could not be secured.

(7) *Xylocopa tenuiscapa*.—The Large Black Bee or the Carpenter Bee: fairly common—though not, by any means, even as numerous as *Apis dorsata* at Yercaud. Being a big insect and of active habits, it visits a larger number of flowers at a time than any of the Honey-bees. It is, however, not a systematic worker; for after visiting flowers on a few branches of a bush it rushes off to another situated at a distance, whereas the Honey-bees (especially *Apis indica*) do not, as a rule, leave any flowers unvisited before departing for the next bush.

(ii) *Wasps*.—I observed two instances where (1) a *Sceliphron* sp. and (2) another Sphegid visited coffee flowers and as far as I could observe, went in for the nectar, but I was unable to catch them.

(iii) *Ants*.—I noted, at least, 6 species of ants visiting coffee flowers. Of them (1) *Myrmecaria brunnea* and (2) *Camponotus paria* (workers minor)—both rather large ants with long legs—were found walking over the flower clusters and occasionally stooping down to the mouth of the Corolla—though the large size of their heads could not have permitted of their reaching the nectar in the nectaries. It is just possible that their long legs might be instrumental in the transference of the pollen from the anthers to the stigmas. The other ants were:—

(3) *Tapinoma melanocephalum*.—This ant was present in large numbers on some bushes and visited the corolla of flowers. Being a tiny ant, it obtained access to the nectaries, but as it did not generally climb up either the stamens or the styles, it seems to have no significance in the fertilization of coffee.

(4) *Monomorium gracillimum* var *mayri* was present in some numbers on a few bushes. They came up from a hole in the ground up the stem and branches and entered the corolla of flowers in search of nectar; they did not run up the stamens or the styles.

(5) *Sima aitkeni* (?)—On some bushes I found a few of these slender elongate ants running up and down leaves and flowers, but though possible it is very doubtful whether they actually transfer pollen to stigmas.

(6) *Acantholepis frauenfeldi*.—Only two specimens of this ant were obtained, one inside the corolla and the other on the petals of the flower.

(7) *Lepidoptera*.—Four different butterflies were noted by me settling on flowers and sucking nectar up with their proboscides, but so far as I could observe they do not seem capable of carrying pollen from one flower to another. Moreover they seem to visit coffee flowers but rarely.

(1) *Hypolimnias bolina*—noted on three separate occasions.

(2) *Neptis eurynome*—on two occasions

(?) *Danais nilgiriensis*—on three occasions.

(4) A *Lycænid* (which I was not able to catch).

(iv) *Moths*.—(1) *Cephonodes picus*.—Observed to be present in most estates. It is a dayflying moth and was to be found at all times of the day from 7 A.M. to dusk. It is very active and flies about with a characteristic humming sound. It sucks up nectar while on the wing and flies from flower to flower very quickly. While visiting flowers, however, the tongue—while it may touch the anthers—does not reach the stigma and it is therefore doubtful how far it is concerned in the fertilization of coffee. When buds are just about to open, however, the stigma alone projects slightly out from the midst of the petals and at this stage, I observed *Cephonodes* thrusting its tongue in (in buds not yet open, it actually forces the proboscis in) and in this case the moth would seem to act as a carrier of pollen.

(v) Along with the blossoms, fresh shoots are also put forth by the bushes after the first rains. I observed the *Cephonodes* moths depositing small yellowish green spherical eggs on the tender buds or young leaves of coffee. Some eggs collected by me hatched on the fourth day into greenish Spthingid larvae with a conspicuous straight black horn. They were fed on tender coffee leaves in breeding cages, but they did not somehow thrive on them and died.

(vi) *Colleoptera*.—(1) A Cetonid beetle—*Clinteria auronotata*—was collected by me from a bunch of partially faded coffee flowers. Probably it feeds on the anthers and stigmas; but I do not think it has much importance as regards the fertilization of coffee flowers.

(2) A Nitidulid of small size was collected from inside the corolla of a coffee flower.

(vii) *Diptera Syrphidæ*—three different kinds were noted on coffee flowers:—

(1) *Syrphus* sp. (?) very much like the *Syrphus* found on *Aphis* in the plains. This was noted on three different occasions on coffee flowers, where the pollen was licked or scraped up with the tip of its tongue from the anthers and later on the style was similarly treated.

(2) (?) *Eristalis* sp. A large fly resembling a bee to a certain extent. It was only once observed by me on coffee flowers—on which occasion I noticed it brushing pollen up with the tip of the tongue, visiting all the anthers by turn. It also licked up the surface of the stigma and later thrust the proboscis down the corollar tube for the nectar. Certainly a useful insect if present in sufficient numbers.

(3) Another *Syrphid* found also on a flower on one occasion.

(4) *Muscidae*: A fairly large fly—once noted on a flower—thrusting the proboscis down the corolla—apparently after nectar.

(viii) *Hemiptera—Pyrrhocoridae* (1) *Serinetha abdominalis*.—This bright orange-yellow bug was noted in large numbers in some coffee estates. Usually they were found either on coffee bushes or on fallen leaves on the soil. Some were noted on coffee flowers as well, but, as far as I could observe, they made no attempt either to seek the nectar or to suck out the sap of flowers.

(ix) *Aphidæ*, (2) *Aphis*.—About five specimens of *Aphis* were found on a single unopen flowerbud. They were tended by a species of *Cremastogaster*.

“4. It is quite possible that, in addition to the insects enumerated above, there might have been a number of insects with decided flower-visiting habits that might have escaped my observation. Especially is this likely to be the case with moths and other nocturnal insects at which time my observations are confessedly scanty. Nevertheless, I feel pretty certain that coffee flowers (setting aside the probability of wind-fertilization) are in the main fertilized by the action of the day-flying visitants of flowers. Of the list of about 29 insects enumerated by me in this report, the really important ones are certainly the following:—

(1) The three honey-bees—*Apis indica*, *Apis dorsata* and *Apis florea*.

(2) *Xylocopa tenuiscapa* and

(3) *Cephonodes picus*.

“5. Of the three honey-bees, it was only *Apis indica* that was found fairly abundant. *Apis florea* was present in but scanty numbers while *Apis dorsata* was absent altogether in some estates I examined. In the coffee flower the pistil is very elongate and the stigma stands well separated from the anthers, so that when *Apis indica* and *Apis florea* visit the flower they are unable—whether while seeking nectar or

while gathering pollen—to reach the stigma. As, however, coffee flowers occur in thick clusters pollen seems to be deposited on the stigmas as the bees step out from one flower to the next. *Apis dorsata* being a bigger insect seems to be better adapted for the fertilization of the coffee flowers. *Xylocopa* is still more efficient in this respect—as by reason of its weight the style is bent down so that the stigma comes in contact with the bushy posterior tarsi which carry abundant pollen.

“6. *Cephonodes*—so far as its visits to fully open flowers are concerned—seems to be of little use in fertilizing flowers. Some pollen may certainly get attached to its tongue while sucking nectar, but the stigma is situated so far above the reach of the proboscis that fertilization through that means appears to me quite impossible. The moth has the habit, however, of visiting just opening flowers where the stigma, which just protrudes out from the flower, is certain to have a few pollen grains deposited on to it as the tongue is thrust in for the nectar. All the other insects appear to me of little significance as compared with the honey-bees, the Carpenter-bees and the Hawk-moth.

Y. RAMACHANDRA RAO,
Second Assistant.”

23rd May 1913.

(2) *Report on a tour to Coorg, in April 1913, by T. V. Ramakrishna Ayyar, Entomological Assistant.*

“On the 17th April a telegram was received from Mr. Jonas, the Scientific Assistant to the Coorg Planters' Association, regarding the flowering of coffee. Under orders from the Entomologist, I left for Sidapur the next day and reached the same on the 22nd morning having been unavoidably delayed at Mysore for two days for want of conveyance to Coorg.

“2. On reaching Sidapur, I heard from Mr. Newbery of Margalli Estate, who was conducting one of the experiments in connection with ‘Coffee blossoms and insects,’ that coffee blossoming was all over 4 or 5 days ago. Apparently I found that the message sent by Mr. Jonas to the Entomologist was late, the same having been received at Coimbatore only on the day on which the blossoms were expected to open at Sidapur (viz., on the 17th April). I went to Mr. Jonas at Rock Hill where also the blossoming was all over. Mr. Jonas showed me the plants on which he was carrying on his experiments in that estate. Asking me to remain at Rock Hill, Mr. Jonas proceeded to Mercara to find out if there were any estates in the north Coorg where some blossoms were still expected to open, so that I might go there.

“3. Meanwhile I remained at Rock Hill making a general collection of all available insects, paying particular attention to insects visiting the coffee plants. Of the latter, there were precious few, now that the blossoms had dropped and the minute berries were beginning to set. I am also informed by Mr. Newbery that this year very few insects were found on coffee even when in blossom. Stray specimens

of Rock Bee (*Apis dorsata*) and the Indian Bee (*Apis indica*) were found flying about in the estate, but hardly any insect of importance was found on the coffee plants. Among those found casually visiting the plants were the following :--

- (1) Two species of bright metallic-coloured Chrysomelids (*Corynodes cavifrons* and *Corynodes sheppardi*).
- (2) A pinkish brown bug, *Tettigoniella ferruginea*.
- (3) The Jak Cercopid (*Cosmoscarta relata*).
- (4) Another bug (*Cletomorpha hastata*).
- (5) Do. (*Odontopus nigricornis*).

" 4. Of the above, Nos. 3 and 5 deserve some attention. The Jak Cercopid (*Cosmoscarta relata*) is found to be a serious local pest of the jak fruit tree in Coorg. The adult is a dark brown insect with reddish marks and of very active habits. The immature insects are generally found within masses of creamy white froth at the stalks of tender shoots and fruits and at the back of soft leaves. About seven or eight of these wingless nymphs are often found within the same mass of froth. In badly infested trees, these frothy masses are found in such numbers that the liquid matter dropping down often wets the soil all round a tree and there appear swarms of bees, flies and other insects attracted by the apparently sweet fluid. Many of the ripening fruits, at the stalks of which these young insects remain feeding, drop down and numbers of unripe fruits are found fallen around badly infested trees. The wingless young insects remain within this frothy mass until they assume the adult state, feeding on the sap of the tender portions of the tree; they are dark brown in colour with light coloured bands across the abdomen; but get a reddish tinge as they approach maturity. They are found quite helpless once they are removed from this frothy matter.

" 5. The other insect (*Odontopus nigricornis*) is a Pyrrhocorid bug; this was found in hundreds all over the estate in all stages. The bright pink coloured nymphs were found in numbers at every turn breeding especially on the fallen fruits of various kinds of trees chiefly species of *Ficus*, *Trewia*, etc.

" 6. I stayed at Rock Hill, Sidapur, for three days. On the 25th evening, I got a message from Mr. Jonas at Mercara asking me to go to Mercara at once. I proceeded accordingly and at the instance of Mr. Jonas, I saw Mr. Hannington, the Commissioner of Coorg, who told me that some blossoms were expected in Hansey Estate in north Coorg and advised me to go there. From Mercara I left for Hansey and on the way at Somwarpet I again saw the Commissioner by appointment and got a letter of introduction to the Agent at Hansey Estate. I reached this place early on the morning of the 29th on which day some blossoms were expected.

" 7. Here again, though there were some blossoms to see, the great majority of them had opened three days ago. There were a few that had opened the day previous to my reaching the estate and some that were opening on the day of my arrival. I had, therefore, blossoms of different ages to see—those that were three days old, those of the second day and some just opening. I was told by the gentleman in

charge and also by others in the different places I visited, that the blossoms begin to fade and gradually drop in from 36-48 hours at the most remaining for a little over two days. By the evening of the 29th, some of the blossoms which had opened early on the morning of the previous day were noted to fade and hardly any insect was observed to visit such flowers. I think fertilization takes place very soon after the blossoms open. The best time for observing coffee-visiting insects, especially those which are likely to play a part in pollination, is, I think, the very first day. I remained at Hansey for the two days 29th and 30th, observing insects visiting old as well as new blossoms and also collecting all other available insects on the estate.

8. As in the case of several garden plants which, when in blossom, are visited by numerous insects even on the plains, I expected to come across a good many insects on coffee blossoms, but it was disappointment. There were comparatively few insects visiting flowers compared to the very rich insect fauna of the tract. The following tabular statement shows the insects noted on coffee flowers with some observations on each:—

Number.	Group to which the insect belongs.	Name.	Time of visiting flowers.	Remarks.
1	Hymenoptera (Apidæ). Bees.	<i>Apis dorsata</i> .	Found all through the day but common between 8 A.M. and 2 P.M.	This insect (Rock Bee) was found fairly common. They are found singly generally, unlike the other bee. Found collecting pollen chiefly. Probably plays some part in fertilization.
2	Do.	<i>Apis indica</i> .	From early morning on to sunset.	The commonest of all insects I found visiting coffee blossoms. More than one bee is found in the same flower. Extremely active both as a pollen collector and a feeder of nectar.
3	Do.	<i>Melipona</i> ..	Common soon after sunrise.	This is the insect often called in the vernacular—the mosquito-bee. It is an indifferent feeder visiting flowers as well as rotting fruits, etc. Five or six of them are often found on the same flower—chiefly feeding.
4	Do.	<i>Anthophora zonata</i> .	Commoner during midday.	Fairly common but not as common as <i>Apis indica</i> but commoner than <i>dorsata</i> . Diligent in collecting pollen with its characteristic hum.
5	Hymenoptera (Apidæ). Wasp.	<i>Polistes stigma</i> .	Early morning.	Several found together, feeds on the nectar. The delicate paper nests of them are found attached to coffee leaves.
6	Hymenoptera (Apidæ). Bee.	<i>Megachile umbripennis</i>	Only in clear sun light.	Actively collects pollen in the pollen brush. Sometimes also found cutting leaves.
7	Hymenoptera (Wasp).	<i>Odynerus fragilis</i> .	All day ..	This is a small solitary wasp often found hidden inside a flower. I think it feeds on the nectar. It is also likely that it comes in to look for caterpillars which it has the habit of collecting and storing.
8	Hymenoptera (Bee).	<i>Oeratina hieroglyphica</i> .	All midday	Not common. Stray specimens come and sit on the flower, not found to remain even a short time on the flower. It is a very small bee.

Number.	Group to which the insect belongs.	Name.	Time of visiting flowers.	Remarks.
9	Hymenoptera (Bee).	<i>Purewaspis cartonaria</i> .	All midday and afternoon.	Commoner than No. 8; found nibbling the nectary.
10	Hymenoptera (Colletidæ).	<i>Prosopeis</i> sp.	In bright sunlight in the morning.	A tiny bee, pretty common, collecting pollen.
11	Hymenoptera Sphegidæ (Wasp).	<i>Oxalro</i> sp.	At midday.	A small dark wasp; nibbles the nectary. Not common. It crawls about the flower stalks; probably in search of Aphidæ which it is known to collect and store.
12	Do.	<i>Trypoxylon intrudens</i> .	In the evening as the sun goes down.	Fairly common; did not note it feeding. It disturbs the flower sufficiently to displace the pollen grains. It is likely searching for spiders for its nest.
13	Hymenoptera (Ant).	<i>Sima</i> (<i>Jerdonii</i> ?).	In the morning and late in the evening.	A small black ant. Goes inside other flowers. Very active; probably collects food for nest.
14	Beetles Cetoniid.	<i>Heterorrhina planata</i> .	At midday.	A very active large shining green Cetoniid. Flies often very high. Found perching on the flowers and often nibbling the petals. While on the flower it is not watchful and is easily caught.
15	Beetles. Chrysomelid.	A reddish brown Chrysomelid spotted with black.	Early in the morning and late in the afternoon.	A fairly large leaf-beetle not very common. Found sitting on flower and leaf. Not noted to feed.
16	Do.	Yellowish Chrysomelid.	All day ..	Feeding on tender leaves and petals of flowers and fairly common.
17	Do.	<i>Monolepta signata</i> .	Early in the morning.	Found chiefly feeding on the tender leaves but few feeding on flowers.
18	Beetles ..	Elaterid beetles.	All day ..	Small black beetles found often hidden inside flowers.
19	Beetles. Glow worm beetle.	<i>Luciola gorhami</i> .	Early in the morning.	These are also found partially hidden in the flowers. Very likely they feed on the pollen.
20	Beetles. Longicorn.	<i>Oberia</i> sp. ..	Found in the morning.	Very few found. I think it is only a casual visitor without any object of feeding on the flower. Not seen to disturb flower with mouthparts.
21	Flies ..	A purple blue Doli-chopid.	In fine sunshine.	Actively visits flower after flower. Probably licks the nectar.
22	Flies ..	A dark Bom-byliid.	Do.	Do. do.
23	Lepidoptera.	Skipper ..	Midday ..	Extremely active, feeds on the nectar; not very common. (Specimen not collected.)
24	Do.	Sphingid ..	Late in the evening.	Actively visiting flowers, not found when approached with lantern. The characteristic hum gives the idea that the insect is a hawk-moth. (Specimen not collected.)
25	Rhynchota. (Bags.)	<i>Melampus fulvomarginata</i> .	Noted only once about 3 P.M.	A purple brown fairly large pyrrhocorid bug, found on a flower with the proboscis thrust into the same, only once.

"9. It was surprising to find that among the bees—the small honey-bee (*Apis florea*) was not only not seen on the flowers but I did not see a single specimen at the time of my visit.

"10. There were some very big *Xylocopa*s—the bluish Carpenter bees—flying high up and perching on trees, but I did not note any on coffee blossoms. It is unfortunate that I was not able to make observations and collect, in the Estates where the experiments were arranged at the time when the blossoms opened in those places; because timely information was not received. Both Mr. Jonas and myself think that for Coorg at least, further experiments and observations should be made next time to enable us to come to any definite conclusion regarding the relation of insects to coffee blossoms.

"11. A good number of other insects were also collected at Hansey. On stray coffee plants, hundreds of immature hoppers of a painted variety were found actually covering the branches. These are probably the young of the coffee locust (*Aularches* sp.); the adult insect was not seen. Probably the eggs had hatched out just after the first coffee showers. I did not find any specific pest of coffee in any of the estates I visited.

"12. I left Hansey Estate on the 1st May reaching Mercara the same night. I saw Mr. Jonas, who was still at Mercara and also showed him my collection the next day. The same evening I left Mercara back for head-quarters.

21st May 1913.

T. V. RAMAKRISHNA AYYAR,
First Assistant."

27. The foregoing notes show that bees of various kinds do visit the coffee blossom, and that they are efficient pollinators, and it may be assumed that their presence is therefore decidedly beneficial and to be encouraged as far as possible. As regards protection of these bees, by legislation or otherwise, we are practically only concerned with one species, the Rock Bee (*Apis dorsata*). The Indian Bee (*Apis indica*) builds a nest composed of several parallel combs which are usually placed in some protected situation, such as the interior of a hollow tree; the Little Bee (*Apis florea*) suspends its small single comb from the branch of a bush or sometimes in a slightly sheltered place such as under the eaves of a house; the Carpenter Bee (*Xylocopa*) nests in dead wood, into which it tunnels so as to be destructive when the situation selected is a roof-beam or other structural timbering: none of these bees are at all gregarious. The Rock Bee (*Apis dorsata*), on the contrary, is markedly gregarious, its large single comb being nearly always slung from a tree or rock which also forms the home of numerous similar colonies. As a rule, the same locality is selected year after year, the bees deserting their combs during the wet season in the Hills and migrating to the plains, returning to the hills after the rainy season and building new combs in the same locality. In Coorg I was told that the bees migrate backwards and forwards twice annually, but a single migration-flight in each direction seems to be the rule, that from the hills to the plains taking place about June and the return flight in November-December.

28. Without a prolonged series of careful counts of the numbers of colonies in a given district it is obviously impossible to say for certain whether the bee-population (by which *Apis dorsata* alone is referred to) is decreasing, increasing or stationary, but residents in the planting districts are almost unanimous in asserting that it is steadily decreasing. As regards the causes which underlie such decrease, they may be ascribed, I think, mainly to the increased opening up of the planting districts concerned and consequent (1) destruction of the primeval jungle and (2) increased facilities for trade.

29. In the case of those colonies of bees which nest in trees it must be remembered that there are comparatively few trees which are suitable. One such tree may contain a hundred or more colonies of bees—one "Bee-tree" which I saw had about 156 colonies on it—and so many colonies require a large amount of branch-space; then again the branches must be fairly horizontal to suspend the combs properly. Before the hill districts were opened up such trees were undoubtedly much commoner than they are now. The present system of shade-trees (*Grevillea* and such-like) over coffee does not provide the bees with suitable trees and the present "Bee-trees" are all, or nearly all, relics of the old jungle. As they decay or are cut down, the bees are compelled to go elsewhere and many colonies probably perish whilst searching for a new home or because they are ultimately compelled to make shift with an unsuitable position.

30. Increased facilities for trade do not at first sight have any bearing on the destruction of bees, but, in cases where the colonies are robbed by jungle tribes, it would seem that a larger and nearer market and better prices lead to a more systematic persecution of the bees for the sake of their products. A jungle tribe which used to rob the nests for its own immediate necessities now destroys every accessible colony to supply the market. This is an economic factor which should not be lost sight of if the necessity for any restrictions on the robbing of these colonies of bees is considered by Government. It seems to me that there is a decided difference between a man who collects jungle produce for his own use and one who collects it for sale to others.

31. The method of collecting the honey and wax has already been described. The bees are always burnt off with a torch and the whole colony is killed as a rule. It has been stated (*Planters' Chronicle*, VIII, 27) that "it is quite easy to take honey and wax without destroying the bees"; so it is, when the bees are in a hive under control. When they are all on a single comb containing honey and young brood, and when moreover this comb is suspended from a branch or rock perhaps a hundred feet above the ground, the matter is very different and I doubt whether any other method would be practicable as a rule.

32. As regards the desirability of legislation to prevent the destruction of bees, it does not appear that there is any necessity for this because the matter appears capable of being dealt with without special enactments. So far as reserved forest areas are concerned, I understand that the right to collect honey and wax is vested in Government under the general heading of "Minor Forest Products"

and that this right is leased out annually by the Forest department to the jungle tribes who collect the honey and wax. Discontinuance of the issue of such licenses should form an obvious and simple check on the destruction of the bees. This applies, of course, particularly to the gregarious colonies of *Apis dorsata*: it is difficult to see that legislation or the non-issue of licenses would prevent in practice the destruction of single nests of *Apis indica* and *Apis florea*, as their nests are commonly robbed when found and the honey eaten on the spot. But, in the case of the large colonies of *Apis dorsata*, which are always found in particular localities, which commonly store honey at particular and well-known times of the year, and for whose taking special preparations have to be made, there should be little difficulty in guarding against illicit interference. As has already been pointed out, the bees desert their nests at regular intervals and permission might be given to collect the wax (old combs) after the bees have flown.

33. In the case of colonies of *Apis dorsata* outside of reserved forest areas, they are mostly found within the limits of the estates of the planters themselves, to whose obvious interest it is to protect the bees from being harried by despoilers and to encourage the bees as far as possible by preserving trees or localities which they have made their head-quarters. No legislation appears to be necessary to effect this: it is a matter for the good sense and co-operation of the planters who are most concerned in the matter.

34. The keeping of bees in hives has been suggested as one solution of the difficulty. For this *Apis dorsata* is unsuitable as it is too fierce and intractable, and *Apis florea* lives in too small colonies to be of much use, besides which the latter bee does not seem common in the planting districts where the conditions evidently do not suit it; in any case, also, both these bees build only a single comb and are therefore unsuited for life in a hive. *Apis indica*, however, building several parallel combs and living normally in hollow trees and similar situations, will adapt itself fairly readily to semi-domesticated conditions in the frame-hive for a short period, but the colonies have strongly vagrant tendencies so that they usually swarm out and fly off again after a few months. By having a dozen or more hives and constantly repopulating them with freshly collected swarms, it is possible to keep at least a few colonies going, but the trouble required is likely to be more than will be taken by any one who is not an enthusiast in the subject of bee-keeping whilst the yield of honey is too small (about 6 lbs. per hive per annum) to repay the cost and labour required for its production. This, however, takes no account of the good done by the bees in pollinating flowers—not only of coffee but of most of the flowers of the garden, shade-trees, green-manure crops, etc.—and it would certainly be advantageous to all estates if a few hives of bees could be kept.

35. *General summary and recommendations.*—(1) The presence of bees is not essential for the successful pollination of coffee, but

(2) The natural, and therefore most desirable, form of pollination is achieved by the aid of flower-visiting insects, of which

(3) Bees are the most important.

(4) Of these bees, the only one which need be considered is the large rock bee (*Apis dorsata*).

(5) There is fairly definite evidence that the numbers of this bee have suffered a steady reduction in the coffee districts of late years, and that

(6) Such diminution is due to (a) to the reduction of suitable nesting-places owing to the opening up of the coffee districts and (b) to the systematic persecution of the colonies of bees in certain districts for the sake of honey and wax.

(7) It is not practicable to take the honey without destroying the bees, but

(8) It is possible to collect the wax without injury to the bees after the latter have deserted their combs which they do at regular times of the year.

(9) In districts in which destruction of these bees occurs on any considerable scale, it were well that the Forest department be requested to refuse the issue of rights to collect honey and wax in forest areas except under special restrictions as regards the number of nests to be taken or the time of year at which they may be taken.

(10) Planters should regard bees as useful allies and do all possible to protect and encourage them within the limits of their own estates.

(11) In any experiments in bee-keeping, the Indian bee (*Apis indica*) is likely to prove the most suitable. (It may be added that the Agricultural department will always be willing to assist would-be bee-keepers with advice and help as far as possible.)

T. BAINBRIGGE FLETCHER.

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